Modeling of ductile fracture using local approach: reliable simulation of crack extension

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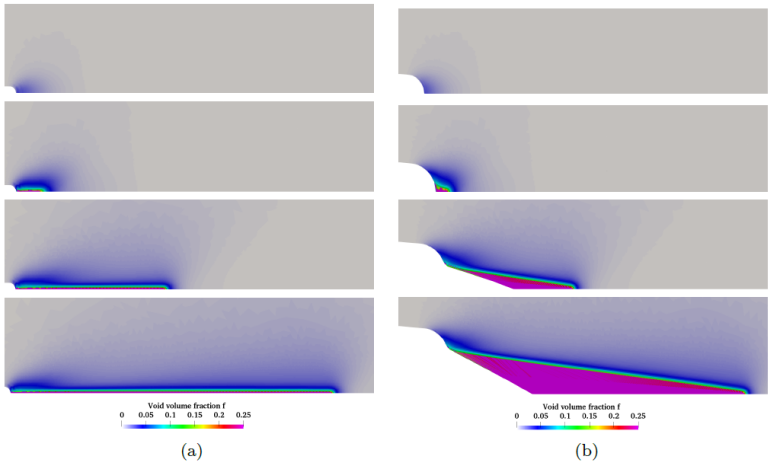

Crack extension in (a) initial (b) deformed configurations in an Infinite Medium (boundary layer model)

- Robustness of non-local model
- Resolution of excessive element distortion problem
- Small-scale yielding model
- Simulations of NT, CT and industrial pipeline (European project STYLE/ATLAS+)

Abstract:

Predicting fracture resistance is important to ensure the safety of industrial facilities under hypothetical accident loads. To achieve this goal, numerous damage models taking into account physical degradation mechanisms have been developed to numerically simulate damage extension. However, the application of these models in structural calculations still remains problematic. The major issues are: mesh dependency and numerical volume locking related to large plastic deformation. These two problems have been identified and one model has been proposed to solve these problems during the thesis work of ZHANG (2016). However, with his model, the reliability of numerical calculations remains poor due to the lack of an appropriate technique to manage crack extension. In these simulations, a Gauss point is considered to be broken once its void volume fraction exceeds a given value. Stress and stiffness at these points are both zero. In that case, the finite elements including these Gauss points can become extremely distorted. This problem appears especially in the damaged

zone and can induce the divergence of simulations. Therefore, the main objective of the thesis, is to find out solutions to prevent this spurious behavior.

The first step of the thesis is to make the current model more robust. Three aspects are or will be addressed:

- Resolution algorithm at integration point level: an improved Newton algorithm, developed by Eric Lorentz, is used. Based on the classical Newton method and the bisection method, this algorithm improves the convergence rate of classical Newton algorithm
- Numerical schemes for solving the internal damage variable: both implicit scheme and explicit scheme are used to update the damage variable
- Void coalescence criterion: Instead of using a fixed value to initiate void coalescence, the plastic limit load model of Thomason will be used. This model indicates that fracture is not only related to void volume fraction, but also to void spacing and stress triaxiality.

The second step is to propose some solutions to prevent excessive element distortions: Use of viscosity to stabilize elements containing broken gauss points: The main idea of this method is to increase the strain rate of the soften element, which gives an additional stiffness to the damaged points. An overlay model (a model which is independent of the inviscid material) is proposed.

The third step is to study some properties of non-local locking-free GTN model using the small-scale yielding model.

The last step is to realize the parameter fitting of GTN model based on the database of the ATLAS+ project. These parameters will be used to realize crack extension in CT3D, SENT3D specimens and in an industrial pipeline. This step is crucial to prove the robustness of the current damage model.